



Risk factors influencing the outcome after surgical treatment of complicated deep sternal wound complications

A. A. Peivandi*, W. Kasper-König*, E. Quinkenstein*, A. H. Loos[†] and M. Dahm*

*Departments for Cardiothoracic- and Vascular Surgery, Johannes Gutenberg- University Hospital, Mainz, Germany and [†]Institute of Medical Statistics, Johannes Gutenberg- University Hospital, Mainz, Germany

Background: Median sternotomy is the most frequently used incision for cardiac procedures but carries a substantial risk for deep sternal wound infections and/or sternal dehiscence. In contrast to previous studies that examined risk factors for sternal infections this study evaluates factors that lead to poor outcome after surgical revision of the non healing sternum.

Methods: Between 1985 and 1999, 193 adults (mean age 64 ± 9 years, m/f = 3/1) necessitated sternal revisions (incidence 1.93%). Pre-, intra- and post-operative risk factors were evaluated for their influence on the outcome after sternal revision.

Results: 65 of the 193 patients had a complicated course: ten (5.2%) died due to sepsis/multi organ failure ($n = 6$) or cardiac causes ($n = 4$). 32 patients (16.6%) needed several revisions, 17 (9%) were discharged with sternal instability, 5 (3%) with chronic fistula and one with persistent osteomyelitis. Univariate and multivariate analysis identified cardiopulmonary resuscitation (odds ratio (OR) = 11.188, $p = 0.010$), corticoid treatment (OR = 7.043, $p = 0.0055$), diabetes (OR = 4.130, $p = 0.0128$), smoking history (OR = 2.996, $p = 0.0041$), renal insufficiency (hazard ratio (HR) = 1.884), old age (OR = 1.108, $p = 0.0266$), high body mass (HR = 1.06), ECC time ($p = 0.023$), cross clamp time ($p = 0.028$), systemic hypothermia ($p = 0.016$), non-use of IMA ($p = 0.042$) or prolonged ventilation as risk factors for mortality or poor outcome. No correlation between sternal closure technique, mediastinal irrigation or antibiotic therapy and outcome after mediastinal revision could be found.

Conclusions: To avoid disappointing results after sternal revision one should aim to preoperatively identify high-risk patients and aggressively address risk factors. This rather than modifications of the surgical and medical approach might improve the outcome of patients with mediastinal complications.

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Introduction

Median sternotomy, as described in 1897 by Milton [1] and 1957 by Julien [2], is currently the mostly

used surgical access to the heart. The post-operative course however can be complicated by sternal wound infection, a potentially life threatening complication, difficult to treat and cost intensive, thereby strongly compromising the institution as well as the patient. For that reason a number of authors had had a look into the causes and risks for sternal dehiscence focusing on pre-, intra- and post-operative factors,

Correspondence to: A.A. Peivandi. Tel.: +49-6131-172911; fax: +49-6131-176626; e-mail: peivandi@mail.uni-mainz.de

which solely or in combination predispose a patients risk for sternal complications.

In this paper we focus on the outcome of those patients, that require repeated surgical procedures in the course of treatment of sternal complications. Risk factors for failure of sternal rewiring were evaluated to develop strategies, that might prevent the need for secondary or tertiary interventions.

Material and methods

Patients

Between January 1985 and January 1999, 9989 adult patients underwent cardiac surgery via median sternotomy at our institution. The outcome of all 193 patients (CABG-surgery: $n = 151$, valve-surgery: $n = 26$, combination of CABG- and valve-surgery: $n = 12$, other: $n = 4$) which had to undergo one or more surgical revisions of their sternal wound was analysed.

Definition of outcome

Three endpoints of outcome were defined: mortality, number of surgical re-interventions before discharge and classification of sternal healing at discharge.

Statistical analysis

All continuous variables are described in terms of summary statistics (n , median, first and third quartile [Q_1, Q_3], minimum and maximum). In the case of normality, mean and standard deviation are given instead of quartiles. Risk factors were evaluated separately using univariate analysis. To account for non-normality, non-parametric statistical test procedures were applied for continuous (Wilcoxon test for independent samples) and contingency tables (Fisher's exact and chi-square) for categorical variables. A multiple stepwise logistic regression analysis determined risk factors independently predictive of poor outcome. The level of significance for all statistical tests was fixed at $\alpha = 0.05$.

Results

Overall mortality in this group was 5.2% (10/193): six patients died of sepsis with consecutive multi organ failure and four of cardiac reasons. 65 (33.7%) patients had a complicated course (Table 1).

Preoperative risk factor

Mortality increased significantly with each additional year of age ($OR = 1.108$, $p = 0.0266$; late patients were 5 years older (median)) and older patients were discharged more frequently with sternal instability or sternal fistula ($p = 0.018$).

Table 1 Outcome of surgical treatment in patients with complicated deep sternal wound complications

Outcome	Patients [n (%)]
<i>Number of sternal revisions:</i>	
One	161 (83%)
Two	26 (14%)
Three	6 (3%)
Total	193 (100%)
<i>Mortality</i>	
State of sternal wound before discharge	10 (5%)
Completely healed	160 (83%)
Sternal instability	17 (9%)
Persistent osteomyelitis	1
Chronic fistula	5 (3%)
Total	193 (100%)

Patients requiring more than one sternal revision were more often diabetics those with only one sternal re-operation (47% vs. 27%, $p = 0.01$) with an odds ratio of more than four ($OR = 4.13$, $p = 0.0128$).

Active smokers as well as ex-smokers had a three-fold higher risk to experience repeated sternal revisions than non smokers ($OR = 2.996$, $p = 0.0041$), corticoid therapy lead to a seven times higher risk for sternal problems ($OR = 7.043$, $p = 0.0055$).

Renal insufficiency ($HR = 1.884$) and a high body mass index ($HR = 1.06$) significantly prolonged hospital stay. With each access kilo body weight the risk increased by 0.6. Other preoperative parameters as quoted in Table 2 had no significant influence on patient outcome.

Intraoperative risk factors

First and second generation cephalosporines were predominantly used for perioperative prophylaxis at the primary operation but the choice of antibiotic treatment did not adversely influence the patients' outcome (Table 3). Duration of extracorporeal circulation (ECC), aortic cross-clamp time, rectal temperature during first time operation and the use of the internal mamarian artery (IMA) for grafting significantly influenced patient outcome: longer ECC ($p = 0.023$) and lower rectal temperature ($X_{med} = 29,5$ °C vs. 32 °C) reflecting the more complicated surgical procedure were associated with higher mortality ($p = 0.004$). In addition low intraoperative rectal temperature was connected ($p = 0.016$) with non-satisfying sternal status at discharge. Patients with sternal problems that had received an IMA-graft died less frequently (2%) than patients without IMA (9%) ($p = 0.042$). Duration of the operation, hemodynamics and method of chest closure had no influence on the outcome.

Table 2 Potentially pre-, intra- and post-operative risk factors in patients with complicated deep sternal wound complications

Risk factors	^a <i>n</i>	^b (%)	^c ($X \pm SD$)	^d $X_{Med} (Q_1; Q_3)$
<i>(a) Categorical variables</i>				
Diabetes mellitus	54	28		
Hyperlipoproteinaemia	99	51		
Chronic renal failure	30	16		
Lung diseases	64	33		
Smoking history	93	48		
Cortisone therapy	11	6		
Urgent or emergency operations	91	47		
Postoperative inotropic support	54	28		
Left internal mammary artery graft	99	51		
Early reexploration for any reason	14	7		
Cardiopulmonary resuscitation	11	6		
Postoperative delirium	29	15		
<i>(b) Continuous variables</i>				
Age (y)	193		64 \pm 9	65 (59;70)
Body mass index	193		27 \pm 3	27 (25;30)
preoperative left ventricular ejection fraction (%)	161		56 \pm 16	58 (45;68)
Operating time (min)	193		189 \pm 62	177 (150;215)
ECC time (min)	193		94 \pm 48	85 (65;120)
Cross-clamp time (min)	193		52 \pm 30	49 (31;65)
Low rectal temperature (°C)	193		31 \pm 3	31 (30;32)
Ventilation time after primary Operation (days)	193		1.5 \pm 2	1 (1;1)
Length of hospital stay (days)	193		41 \pm 24	35 (27;50)

^aNumber of patients = *n*.^bFrequency = %.^cMean and standard deviation = $X \pm SD$.^dMedian [first and third quartile $X_{med}(Q_1, Q_3)$].**Table 3** Choice of antibiotic as perioperative prophylaxis at primary operation

Antibiotics	^a <i>n</i> (%)
First generation cephalosporins	107 (56%)
Second generation cephalosporins	61 (32%)
Third generation cephalosporins	6 (3%)
Carbapenems	2 (1%)
Macrolids	15 (8%)
Glycopeptids	1
Chinolones	1
Total	193 (100%)

^aFrequency [*n* (%)].

Postoperative risk factors

Cardiopulmonary resuscitation had a significant input on patients outcome, mortality was eleven times higher ($OR = 11.188$, $p = 0.010$). All patients extubated on the day of primary surgery, which later had sternal rewiring, were discharged with excellent wound healing. With increasing number of rewiring procedures hospital stay a significant prolongation of hospital stay was noticed (rewiring >1 : $X_{med} = 46.5$ days vs. rewiring = 1: $X_{med} = 32$ days, $p < 0.0001$)

and those patients with non-optimal wound healing stayed longer ($p = 0.008$).

Surgical and mediastinal rinsing techniques

In the first and second rewiring operation either sternal wires or sternal wires in combination with sternal tapes were used. During third time re-interventions plastic reconstructive measures (muscle flaps, omentum or open wound treatment, [Table 4](#)) were applied, but the choice of technique did not influence the patients outcome.

More than half of the patients had mediastinal rinsing established during first rewiring either with crystalline solution or Lavasept® or polyvidon-jodid. Statistical analysis did not show an influence of the method of rinsing on patients outcome ([Table 4](#)).

Antibiotic treatment after rewiring and microbiologic findings

Despite the fact that more than half of the routinely taken intraoperative microbiologic swabs were positive, predominantly with gram positive bacteria, with persistence into the post-operative period ([Table 5](#)), neither this finding or the class of bacteria nor the choice of antibiotics had significant influence on the outcome.

Table 4 Sternal closure techniques and methods of mediastinal rinsing

	1. time ^a	2. time	3. time
<i>(a) Sternal closure techniques by revision:</i>			
Wires only	86 (45%)	9 (5%)	
Tapes only	11 (6%)	2 (1%)	
Suture only	2 (10%)		
Combination of wires and tapes	93 (48%)	12 (6%)	
Combination of wires, tapes and plastic reconstruction (major pectoral muscle)	1	6 (3%)	
Omentum plastic only		1 (0.5%)	
Major pectoral muscle plastic only			3 (1.5%)
Combination of major pectoral muscle and m. rectus abdominis-plastic		2 (1%)	1 (0.5%)
None/Open wound treatment			2 (1%)
Total	193 (100%)	32 (17%)	6 (3%)
<i>(b) Methods of mediastinal rinsing:</i>			
None	11 (6%)	9 (5%)	5 (2.5%)
Crystalline solution	89 (46%)	12 (6%)	
Polyvidon-jodid	39 (20%)	3 (2%)	
Lavasept	54 (28%)	8 (4%)	1 (0.5%)
Total	193 (100%)	32 (17%)	6 (3%)

^aFrequency [*n* (%)].**Table 5** Microbiology of sternal wounds: *t*₁ = sternal rewiring time (intraoperative), *t*₂ = 1. control (3 days after 1. rewiring), *t*₃ = 2. control (5–6 days after 1. rewiring), *t*₄ = 3. control (8–10 days after 1. rewiring)

	<i>t</i> ₁	<i>t</i> ₂	<i>t</i> ₃	<i>t</i> ₄
Negative microbiologic findings	59 (31%) ^a	78 (40%)	79 (41%)	82 (43%)
Positive microbiologic findings (total)	115 (60%)	96 (50%)	87 (45%)	80 (42%)
Unknown	19 (10%)	19 (10%)	27 (14%)	31 (16%)
Gram positive bacteria	89 (46%)	75 (39%)	66 (34%)	62 (32%)
Gram negative bacilli	6 (3%)	4 (2%)	3 (2%)	5 (3%)
Gram positive bacilli	2 (1%)	2 (1%)	4 (2%)	3 (2%)
Fungal infection	0	0	0	1
Polymicrobial	18 (9%)	15 (8%)	14 (7%)	9 (5%)

^aFrequency [*n* (%)].

Discussion

Median sternotomy is the standard surgical access to the heart but carries the well known risk of deep sternal wound complications. In the past several studies looked for factors predisposing for sternal dehiscence after sternotomy. Advance age [3–6], especially over 74 years [4], obesity [7], diabetes and renal insufficiency [8] were identified as relevant risk factors. One substantial risk factor that can be influenced by change in life style is smoking [7, 9–10]. The use of the internal mammary as bypass graft significantly increases the incidence of wound infections and sternal dehiscence [11–14], which rises further if the IMA is used in diabetics [3, 4, 12, 15] or bilaterally [4]. This is due to a up to 90% reduction of blood flow in the ipsilateral sternum after preparation of the IMA regardless of the of technique used [14] underlining the need for careful surgical technique during preparation [16]. Reports differ concerning

the influence of extra-corporal perfusion on the occurrence of sternal complications [3, 11, 17–18].

In contrast to these studies our evaluation focuses on risk factors for poor outcome after sternal rewiring especially under the aspect how these risk factors might be influenced.

We confirmed that most of the factors responsible for initial failure of sternal healing are of equal relevance during the course after rewiring. Our findings stress the higher mortality rate of older patients undergoing sternal re-intervention. Obesity is related to significantly longer hospital stay and more complicated wound healing and remains one of the factors that should be approached before the operation. In contrast to a study by Demmy performed in patients with first time cardiac surgery [6], in which steroid therapy did not reach significance level as a risk factor, our study proved a significant sevenfold increase in sternal problems in patients with ongoing or shortly interrupted steroid therapy. Patients with a

given indication for steroid treatment should therefore be identified and more closely monitored or — if possible — medication should be discontinued. Diabetes mellitus has a negative influence on wound healing after rewiring. The high incidence (about one third of our study patients had diabetes) stresses the necessity to preoperatively (before the initial operation) and perioperatively aggressively treat abnormal blood sugar levels. Zerr [19] published in 1997 a retrospective study showing that patients who later developed sternal infections had elevated blood sugar levels predominantly during the first two days post-operatively. Applying a protocol of strict control of blood glucose levels via i.v. insulin (blood sugar below 200 mg/dl) during the first and second post-operative day the incidence of sternal infections dramatically decreased. The susceptibility of diabetics regarding wound-healing problems is caused by their microangiopathy [19] and immunologic deficits [20–22]. As control of blood sugar levels is easy to achieve it should be done meticulously in all diabetics during the early post-operative phase.

The above described risk factors centre on constitution and/or health status of the patient, smoking on the other hand is a controllable exogenous risk factor. Smoking increases the risk of repeated procedures after sternal rewiring by factor three, prevention would be highly desirable.

The use of IMA as mentioned above increases the risk for the development of sternal problems but as clearly demonstrated in our study reduces the patient risk during management of sternal complications.

The relationship between body temperature during the primary procedure and outcome after sternal revision reflects that lower body temperatures are applied in those patients facing a more complex surgical procedure. This also applies to the duration of extra-corporal perfusion and cross clamping. Mortality in patients undergoing rewiring was significantly lower in patients with shorter cross clamp and shorter extra-corporal perfusion time. The overall low mortality in patients with short bypass duration and cross clamp times in our study group harmonizes well with results found in literature [3, 12, 18, 23].

Longer intubation time and cardiopulmonary resuscitation (CPR) were post-operative factors with negative influence on outcome. Postoperative CPR increased mortality by factor 11 as well as the risk for sternal complications. It should be mentioned that duration of intubation is not an independent risk factor but a short ventilation time mirrors an uncomplicated post-operative course. This is in concordance with results for primary sternal problems, where patients with sternal complications had a much longer period on the ventilator compared to patients with uncomplicated wound healing [17, 18].

Interestingly neither the choice of perioperative

antibiotic regimen nor the technique of sternal closure or the choice of mediastinal rinsing solution did significantly influence patients outcome after rewiring.

Conclusion

Pre-, intra- and post-operative risk factors have a much stronger influence on the outcome after surgical therapy of deep sternal wound complications than operative strategies. Therefore identification of high risk patients and aggressive treatment of risk factors might improve the results after sternal revision.

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